ELECTROCHEMICAL METHODS TO IMPROVE THE WEAR RESISTANCE OF COATING DEPOSITED ON THE METAL SURFACE

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Resume

It was established that existing methods show low accuracy when assessing the durability of coatings. Furthermore, they don't allow assessment of the contribution into durability of structural components and fillers for thermodiffusion and polymer-composite coatings, respectively.

A method to evaluate durability of thermal diffusion chrome coatings on carbon steel and gray cast irons has been developed - the speed υ_p of destruction of the structural components of the coating. In addition, the destruction of each structural component is characterized by a constant value of destruction speed υ_p and potential φ, and their sharp vibrations are in complete destruction of the coating and the beginning of the destruction of the base metal. From the start of the test until the abrupt change in the rate of destruction υ_p, which is found on the curve υ_p - τ is the assessment of durability coating τ_{∂} hat is specified with the curve φ - τ. Accuracy of the durability decreases from ± 30 min to ± 2 min.

Developed as a way to assess the durability fillers polymer composite coatings, along with the finding that the rate of destruction υ_p of the time includes total disability coverage $\tau_{заг}$ and time breakdown cover τ_n which are fixed on the curve φ - τ.

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Summary

This paper describes the way to assess the durability thermodiffusion, polymeric and polymeric-composite coatings in their cavitation-erosion wear in electrolyte environments.

1. Introduction

Units with magnetostrictive vibrator (MV), shock-erosion stands (SES) and hydrodynamic tube (HT) is common to determine the cavitation-erosion resistance [1]. Under such conditions cavitation resistance of materials is being determined by loss of weight or volume during 1 - 3 hours of testing. The disadvantage of this method is that the structure and phase composition vary in coating thickness and consequently changing weight loss occur. So, in the process of the cavitation steel wear after gas nitriding, the speed of ε-phase destruction during testing in SES is 60 - 65 microgram per hour, in nitride zone the speed of α-phase destruction is microgram per hour [2]. The research which was carried on the unit of MV demonstrated that the rate of cavitation wear of carbide

coatings remains constant within the limits of carbide component bordering on alloyed material, then the chances of destruction increase dramatically and after that follows the catastrophic destruction of the surface area [3]. Therefore, assessment of cavitation wear resistance of coatings must include an assessment of the durability of its structural elements, which makes it possible to optimize the structure of the coating by increasing content and depth of cavitation-resistant phases.

While evaluating the cavitation wear resistance of coating relating to weight loss and in order to obtain reliable data the time settings of cavitation on the units of MV is about 60 minutes. In this case, the accuracy of the durability remains approximately within 30 min.

2. Methods of research

Thermodiffusion plating samples of steel 45 and cast iron 20 which was conducted in unsealed containers in the powder mixture (50 % - $FeCr_2$, 43 % - Al_2O_3 and 7 % - NH_4Cl) at temperature of 1100 °C and diffusion time up to 6 hours. Research on cavitation erosion-resistance was carried out on the unit of MV under such conditions: 1) the oscillation frequency of the vibrator 22 kHz; 2) the temperature of 23 °C in the 3 % solution of sodium chloride; 3) vibrator oscillation amplitude is being 36 microns.

The efficiency of the developed method was researched in terms of polymeric-composite coatings based on epoxy resin ED-16, as a filler there was used a blend consisting of refractory metal carbide of 20 - 100 microns grain size. The composition I contained 230 % (by weight) and composition II – 270 % filler. The compositions containing the filler of 130; 170 and 190 % (by weight) were obtained as well.

The tests were carried out on the unit of the magnetostrictive vibrator in 3 % solution of sodium chloride at the temperature of 23 ± 2 °C.

3. The results of the experiments and their discussion

The objective of this study are: 1) to assess the impact of structural phase components of the coatings on the cavitation-erosion wear resistance; 2) to improve the assessment reliability and assessment accuracy of the durability of thermodiffusion coatings.

The task is set solved by the point that the assessment of the durability is made not in the terms of loss in weight (1) or volume (2), but taking into account the destruction speed of structural components of coatings:

$$\upsilon_p = \frac{\Delta m_i - \Delta m_{i-1}}{\Delta \tau} \cdot s \quad (1)$$

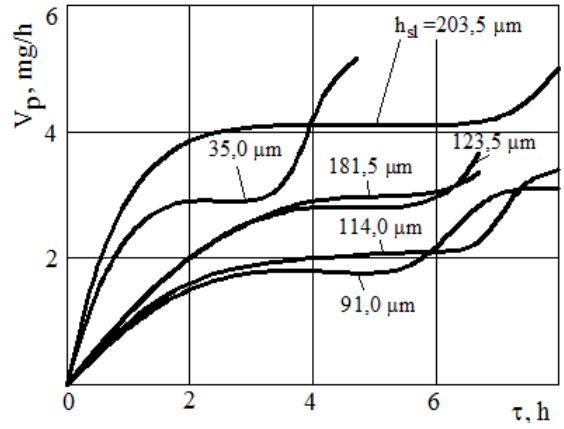
$$\upsilon_p = \frac{\Delta V_i - \Delta V_{i-1}}{\Delta \tau} \cdot s \quad (2)$$

Here $\Delta m_i - \Delta m_{i-1}$; $\Delta V_i - \Delta V_{i-1}$ losses, respectively, of weight or volume of the sample (mg.mm^3) during the test τ per unit of surface of the sample S, cm^2.

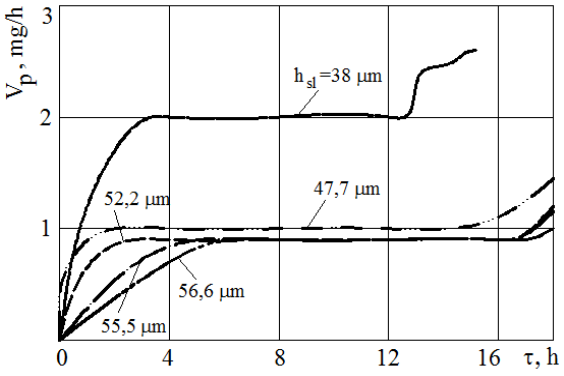
In addition, parallel to potentiostate relieve dependence potential - the time of the test (φ - τ). The destruction of each structural component is characterized by constant speed value υ_n and destruction potential φ, and their sharp fluctuations are the evidence of the complete destruction of the coating and the beginning of the destruction of the base metal. The time from the start of the testing up to the the abrupt change in the speed of destruction υ_n, which appears on the curve υ_n - τ is used for the assessing the durability of coating τ_∂ specified by the curve φ - τ.

Research of powder-chromed steel samples of 45 size and cast iron 20 was carried out on the unit of MV. It was processed in a 3 % solution of sodium chloride shown (Fig. 1).

The test demonstrated that in the initial period the rate of destruction increases, then over a period of time it remains constant due to the uniform destruction of carbide zone of the coating. In the process of the destruction of the carbide area the speed rate increases dramatically as the destruction of the zone of alloyed material goes through localizing microshock burden on defects in the form of pores, inclusions and for this reason it spreads in depth of the coating, which along with an increase in the speed causes irregularity of the destruction.



a)



b)

Fig. 1. Kinetics of change of speed destruction υ_p thermal diffusion chrome coating on steel 45 (a) and gray cast iron SCH20 (b) in 3% solution of sodium chloride, depending on the thickness υ_p of carbide zone coating.

Uneven destruction of carbide zone is shown at the "cavitation potential – cavitation time" curve (φ - τ) by sharp fluctuations of potential (Fig. 2).

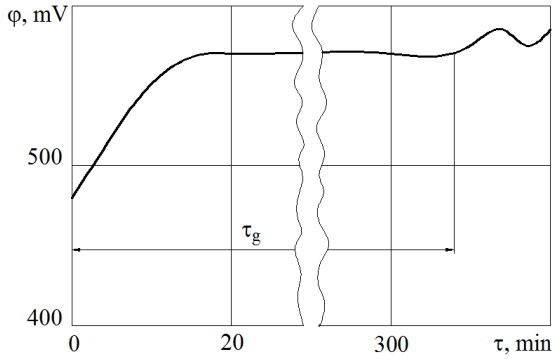


Fig. 2. Kinetics of potential change chrome finish in a 3% solution of sodium chloride (45 steel, carbide zone thickness h_{sl} = 91 microns).

Coatings with different thickness of carbide zone have different speeds of destruction υ_p (Fig. 1). Thus, when the thickness of the carbide zone on the steel 45 h_{sl} equals 35; 91; 114; 123.5 mm, set speed of destruction reached, respectively, 2.9; 1.5; 20 and 2.7 mg·cm^{-2}·h, and the durability determined by these dependencies were 200; 300; 340; 360 min, respectively. Using the dependencies of "potential – time" of testing (φ - τ), which were received directly in the process of cavitation destruction of samples, we obtain revised values of durability, namely 242; 306; 340 and 353 minutes, respectively.

Thermal diffusion chroming of cast iron 20 performed similarly to chroming of samples of steel 45. Cavitation wear resistance was determined by placing the bottom of the sample that an increase in the time trials to prevent it cracking and fracture at the site of attachment.

The durability of the coating with the thickness of the carbide zone $h_з$ = 38 microns following the curve of the rate of destruction – time of the test (υ_p - τ) is 720 minutes, and the dependence of the potential – time of cavitation (φ - τ), respectively, 736 min.

In a similar manner the durability values were obtained for the other samples with different thickness of carbide zone [9].

The downside of the durability evaluation of polymeric coatings by the weight loss is the inability to compare the results of tests of various polymers with each other due to the large difference in density of polymers. In addition, at the time of cavitation bubbles activity on a dual layer system with different acoustic properties (coating-substrate), shock waves partially reflected from the substrate and passing in the opposite direction, which causes the tangential stresses and hence shear strain plots surface coating. The later causes detachment of the coating from the substrate surface and subsequent separation of the detached sections of the coating. In the subsequent cavitation is the destruction of the basic material (substrate) is in progress, which is also taken into account when assessing the durability of the coating.

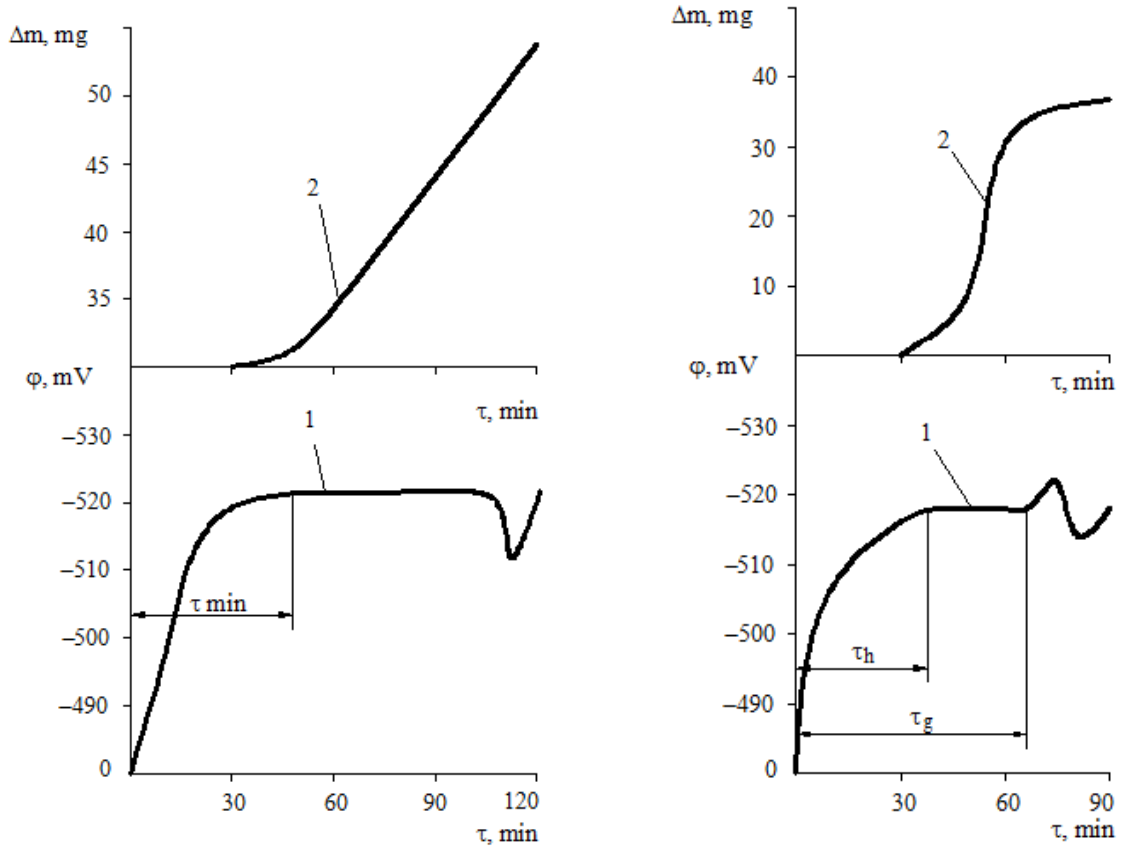
The goal to the basis of the method developed was to improve the accuracy of the assessment of durability of polymeric coatings and polymer composite in cavitation-erosion wear in environments, wear in the electrolytes environment, obtaining the comparative stability of polymers, optimizing of their content structure and ratio of component filler, coating thickness, and so on.

Establishes goal is achieved by the fact that during the sample cavitation in the electrolytes environment along with their weighting within a certain time frame of testing with the help of potentiostat the kinetics of potential φ - τ is taken off and recorded. A method is different in a manner that the coating durability assessment is carried out not by the loss of weight, but by the time of the overall performance of the coatings τ_g and the time of coating's destruction τ_h that are fixed on the curve φ - τ (Fig.3).

Assessment of the total time performance coatings τ_g is performed by the time frame from the start of testing until the abrupt potential change after reaching the values characteristic of the sample without coating. Further sharp fluctuations of the potential characterize the destruction of the surface of the material. Studies have shown that when a time τ_g is reached more than 50 % of the sample was free of coating. On the part of the coating that remained observed deep ulcers, dug and shells that penetrated down to the base metal sample.

All polymer coatings are characterized by the part of the coating with a constant speed υ_p of destruction, which describes linear dependence on the curve Δm - τ (Fig. 3). This region corresponds to a uniform coverage thickness reduction and minor deviations in potential on the curve φ - τ from the potential of the base metal in the given environment. The time from beginning of the test until a curve's potential reaches the φ – τ values within the values close to the potential of the base metal in the given environment was treated as a time of coating breakdown τ_h. At this point in time due to the formation of microcracks the microvolumes penetration into the coating material happens and, under certain conditions of overlapping of microcracks, the contact of the environment with the base metal is achieved.

A method for the assessment of durability of polymeric coatings and polymer composite by two parameters τ_g and τ_h was developed that allows to more accurately assess durability of wear resistance, get comparative data of durability, which is especially important in assessing the durability polymer composite polymers with different filler content. It can also be used to optimize the thickness, content and the ratio of components in the cover etc [10].



a) *b)*

Fig. 3. Kinetics of changes in potential (1) and the mass loss of the sample (2) with a composition I (a) and composition II (b).

The result of the studies for the composition I: the total capacity of the coating layer τ_g =115min, a breakdown layer τ_h = 40 min (Fig. 3a). For composition II: τ_g = 45 min and τ_h = 20 min (Fig. 3b). Weight loss for 1 h of the tests are 54 and 41 mg, respectively, for the composition I and II. Thus, the sample composition over time and 2 times dominated composition II and is 2.56 times the total time performance, and the mass loss of only 1.32 times.

The proposed method of the durability estimation also allows you to find the optimal value, as in this case, between the epoxy resin and the number of filler. Dependency curve τ_g and τ_h from the filler percentage (Fig. 4.) show that the most effective compositions containing a filler within 190 - 230 % range. With less filler increases τ_n, which is associated with an optimal ratio of strength and elastic properties of the coating. With increase of the τ_h value decreases, but τ_g increases dramatically due to increase mechanical properties of the coating layer.

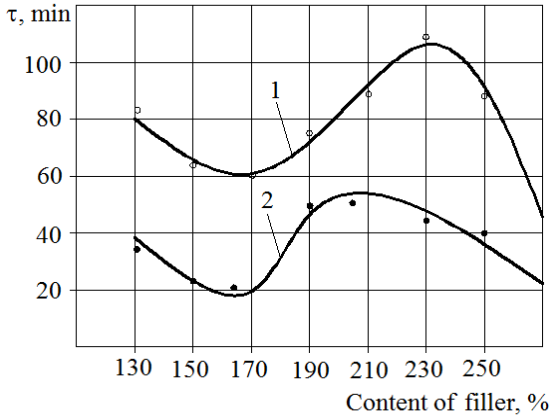


Fig. 4. The dependence of the overall longevity τ_g (1) and time of breakdown (2) and the volume of filler, %.

Thus, the proposed method allows to optimize the composition for coating filler amount. Similarly, it is possible to optimize for grain size composition filler, the ratio of carbides, the thickness of the coating.

4. Conclusions

1. As a result of research we developed a way to assess the durability of thermodiffusion carbide coatings by the speed of carbide fracture and the improved value of durability is determined by the kinetics of potential change in the cavitation fracture surface.

2. Developed also a way of finding longevity of polymer composite during their cavitation-erosion wear in medium-electrolytes, that includes a kinetic curve of mass loss Δm - τ and coating durability assessment is carried out by time its overall performance τ_g and its breakdown time τ_h that are inscribed on the curve φ-τ and are made consistent with the respectable changes of kinetics curves of weight loss Δm - τ.

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